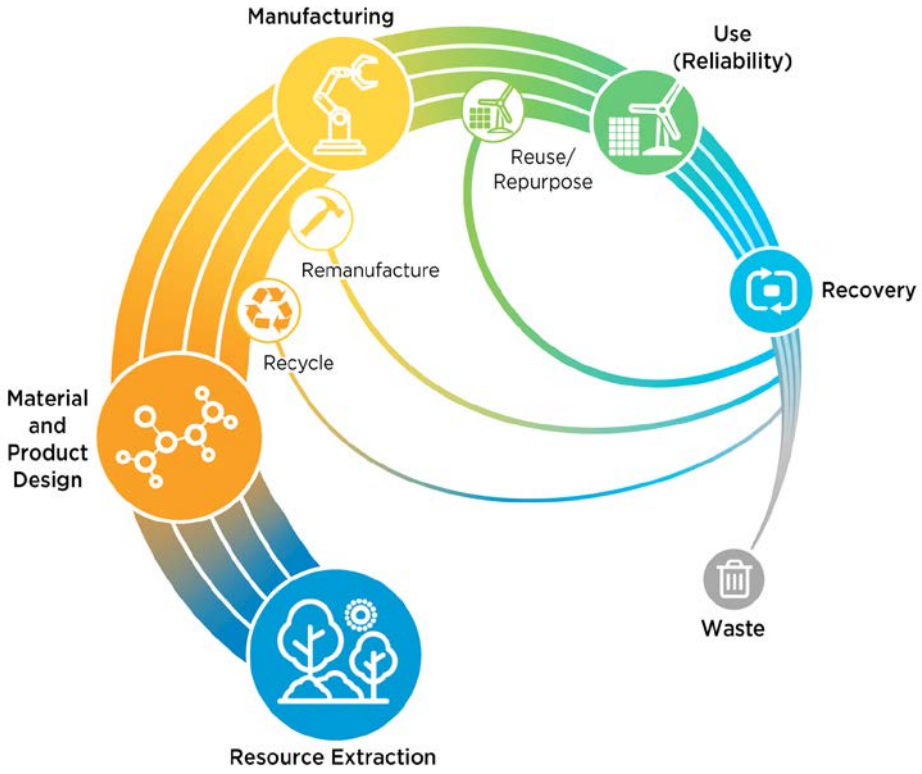

Short-Lived Modules Need to be Efficient, Lightweight, and Circular for the Energy Transition

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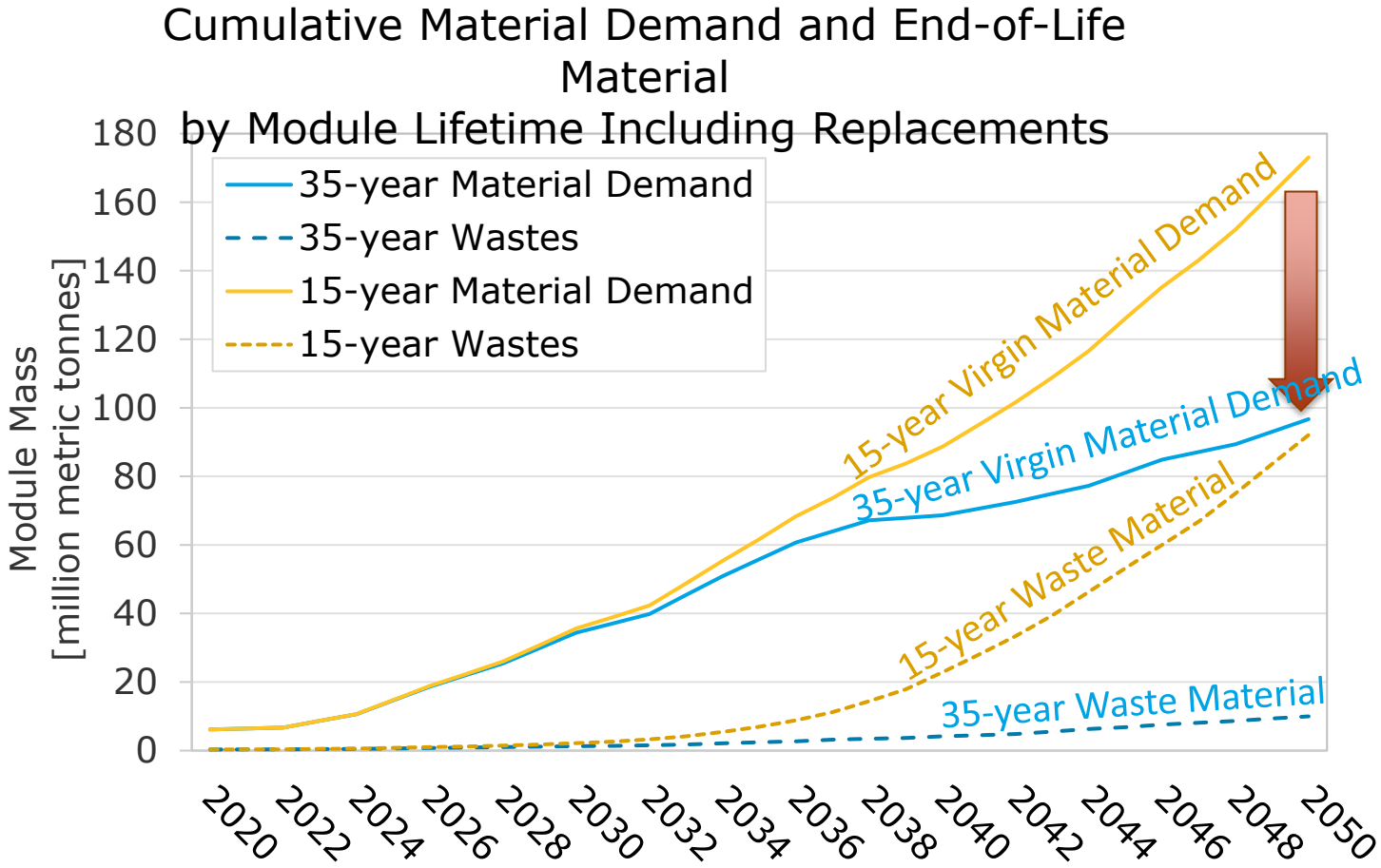
With Silvana Ovaitt and Teresa Barnes

PVRW 2022 Poster

PV Material Demands for Energy Transition

The Situation

- Minimizing material demand will minimize environmental impact
- Emerging PV aims for high efficiency, high circularity, but short lifetimes
- Previous Work: 15-year module requires 1.4 TW of replacement modules, increasing virgin material demand 1.75x
- **What BOM, Efficiency, and Circularity will reduce the Virgin Material Demand of a 15-year module below a 35-year module?**



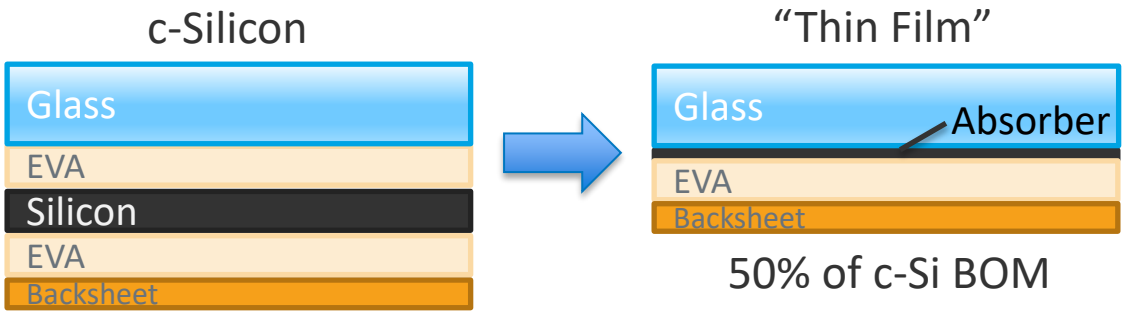
Module Life	Virgin Material Demand [million metric tonnes]	Lifecycle Waste [million metric tonnes]
35-year	97	9.7
15-year	170	92

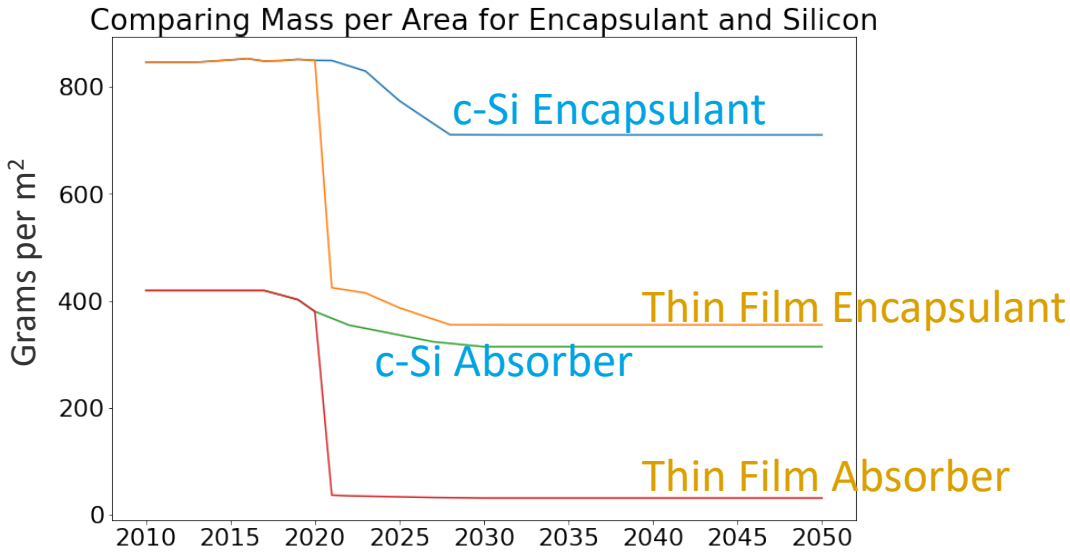
The Experiment: Modify BOM and Module Efficiency

1) Module Lifetime & Circularity Approach

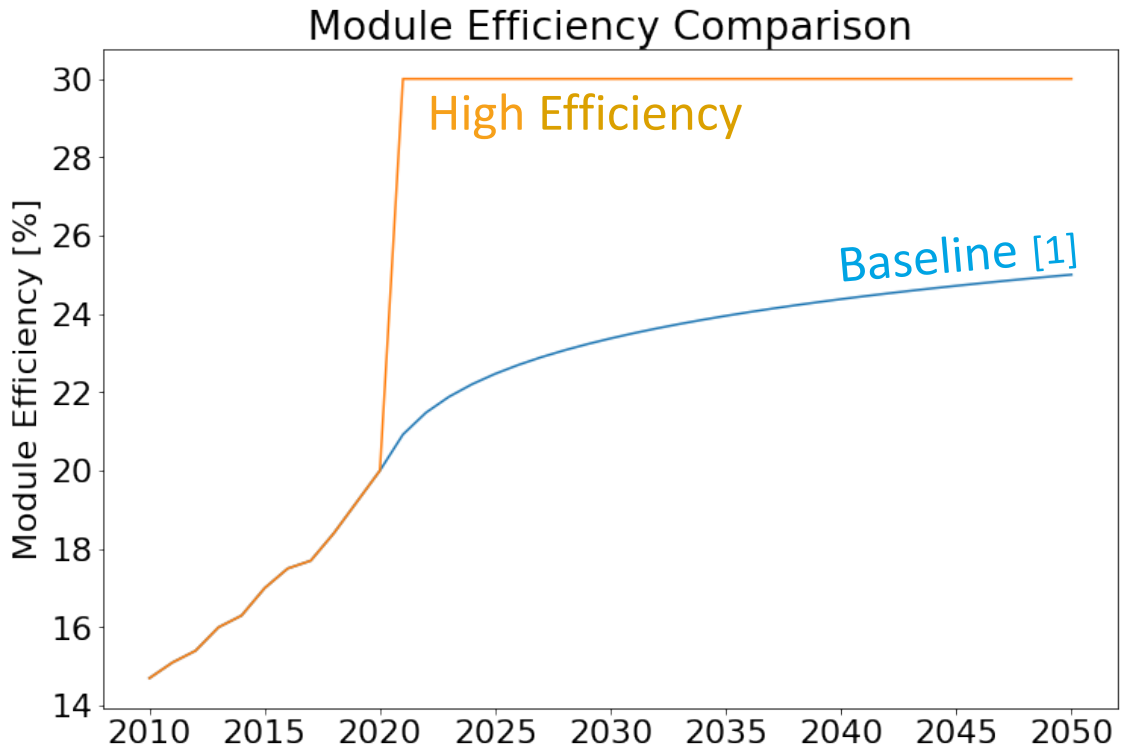
35-yr vs 15-yr with closed-loop recycling

2) Bill of Materials (BOM) Modification





3) Module Efficiency Modification



[1] S. Ovaitt & Mirletz, H. Mirletz, S. Seetharaman, and T. Barnes, "PV in the Circular Economy, A Dynamic Framework Analyzing Technology Evolution and Reliability Impacts," *ISCIENCE*, Jan. 2022, doi: https://doi.org/10.1016/j.isci.2021.103488.

Results:

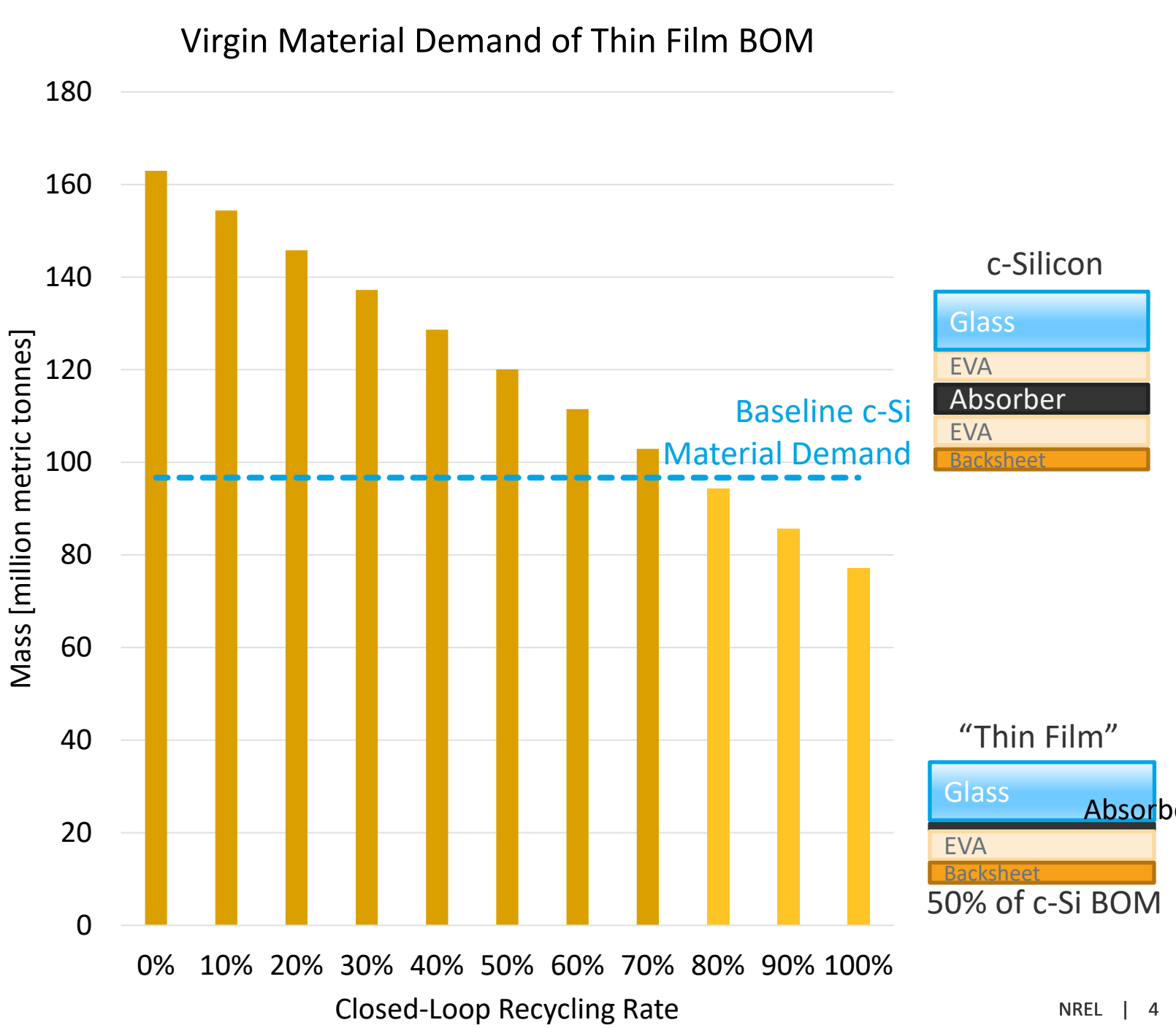
“Thin Film” Design

=

Lower Circular Requirements

Reducing BOM by 50% lowers closed-loop recycling requirement to 80% from 95%.

Currently, no PV module technology is >80% closed-loop recycled for ***all*** materials



Results:

Increased Efficiency

=

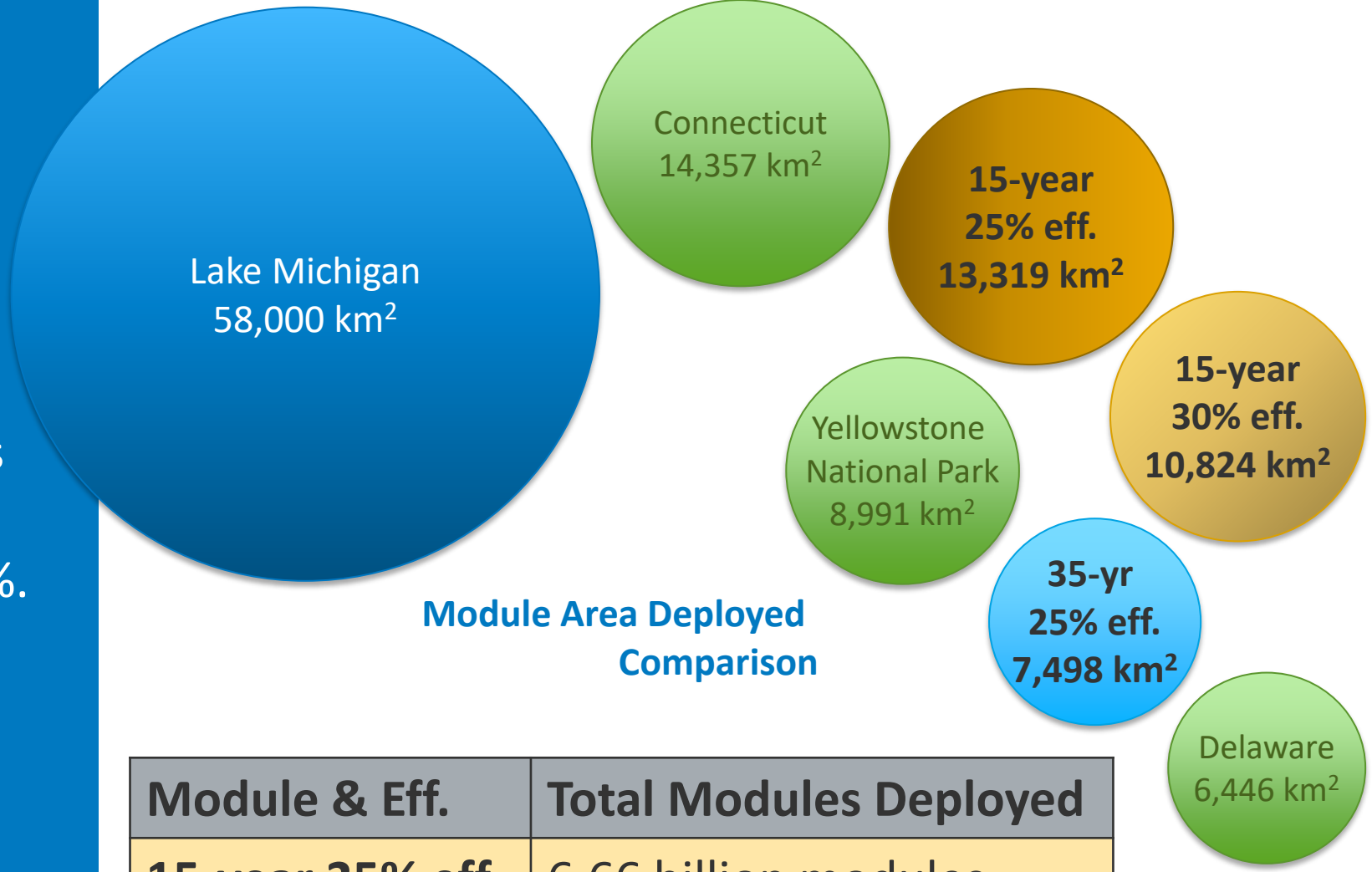
Reduced Modules

30% module efficiency lowers closed-loop recycling requirement to 65% from 95%.

~1.25 billion fewer modules

Still requires 1.66 billion more modules than a 35-yr, 25% efficient module.

*Assuming module area = 2 m^2



Module Area Deployed Comparison

Module & Eff.	Total Modules Deployed
15-year 25% eff.	6.66 billion modules
15-year 30% eff.	5.4 billion modules
35-year 25% eff.	3.75 billion modules

Conclusions & Future Work

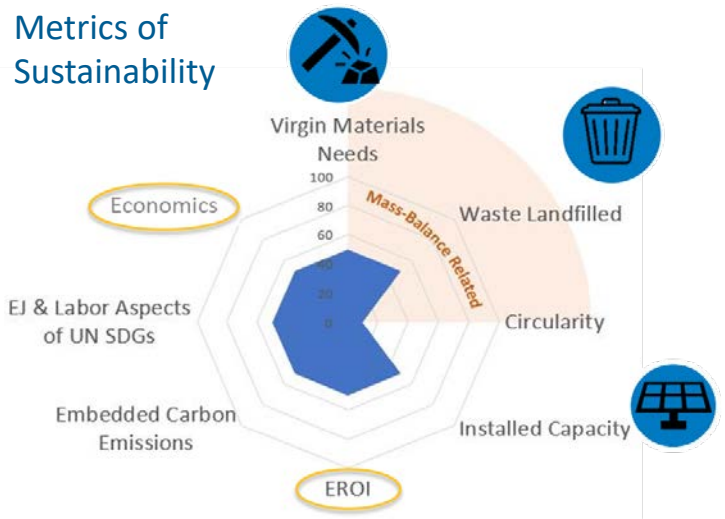
Conclusions

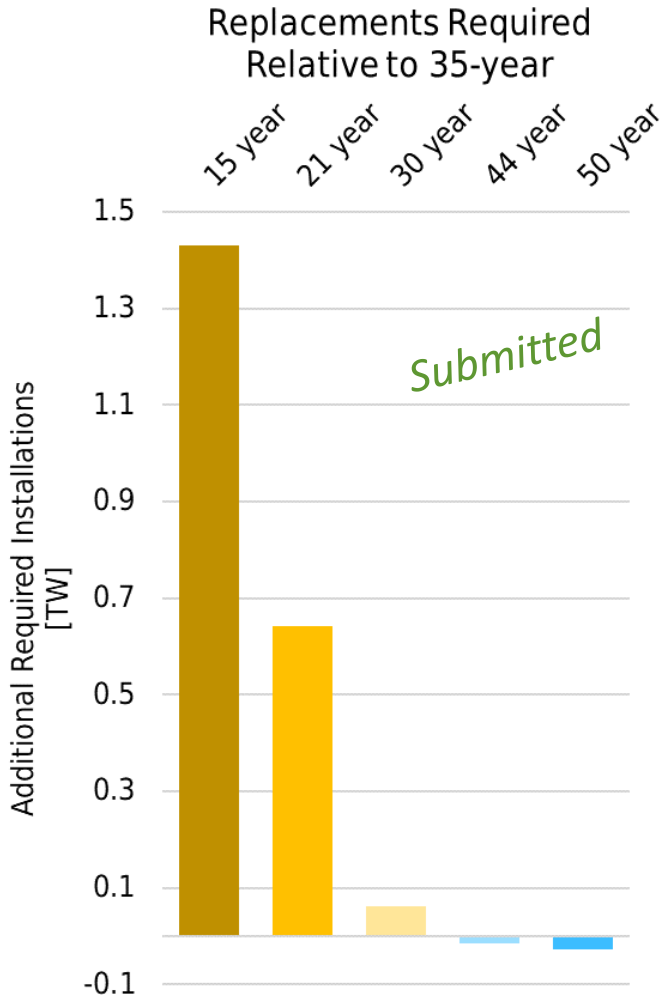
If deploying a 15-yr module, material demands can be reduced by:

- Increased Efficiency >> Lightweight
- Still requires >65% circularity
    - No PV technology is circular for all materials

Overall

- Module lifetime >> Increased Efficiency >> Lightweight





H. Mirletz, S. Ovaitt, S. Sridhar, and T. Barnes, "Circular Economy Priorities for Photovoltaics in the Energy Transition," *Nature Energy*, ***Submitted*** Feb. 2022.

Thank you

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https://github.com/NREL/PV_ICE

NREL/PO-5K00-82288

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